The densification agent may be a polar liquid. In a preferred embodiment of the invention, the densification agent is an aqueous liquid, e.g. water or demineralised water.

When the densification agent is an aqueous liquid, the bulk particulate material, prior to densifying thereof, may include water in a mass concentration falling in a range with a lower limit of about 0.5 %. The lower limit may however be as low as about 0.45 %, or even as low as about 0.4 %. An upper limit of the range may be as high as about 10 %, or even higher at about 15 %, or even as high as about 20 %.

It is however to be appreciated that the bulk particulate material being densified may affect the effective range within which an aqueous densification agent can be used. The aforementioned ranges are however suitable for the densification of microsilica, such as silica fume.

The bulk particulate material may be a hygroscopic material. The bulk particulate material may be microsilica, e.g. fumed silica, precipitated silica, colloidal silica or silica gel.

Instead, the bulk particulate material may be selected from the group consisting of carbon black, fly ash, kaolin, and meta kaolin. Also, the bulk particulate material may be selected from the group consisting of Mn_2O_3, Mn_3O_4, V_2O_5, cement and slag.

When the bulk particulate material is particulate silica, the particulate silica may have a particle size of the less than 0.5 µm, typically less than 0.2 µm. Indeed, it is expected that the invention will find particular, though not exclusive application in densifying so-called silica fume.

The method may include adding the densification agent to the bulk particulate material, prior to or during mechanical agitation of the bulk particulate material.

DENSIFYING OF A BULK PARTICULATE MATERIAL

THIS INVENTION relates to densifying of a bulk particulate material. In particular, it relates to a method and to apparatus for densifying a bulk particulate material.

According to one aspect of the invention, there is provided a method of densifying a bulk particulate material to provide a densified flowable bulk particulate material, the method including mechanically agitating the bulk particulate material in the presence of a densification agent thereby to provide a flowable bulk particulate material of increased bulk density.

The densification agent will typically be a liquid, although it is not excluded from the scope of the invention that the densification agent may be a gas or a vapour, or even another particulate material. It is however a feature of the invention that it is not necessary to remove the densification agent after having densified the bulk particulate material in order to obtain a flowable bulk particulate material. The densification agent is thus present or used in quantities small enough to ensure that the densified bulk particulate material remains flowable and does not form a slurry. The quantity of densification agent remaining in the densified flowable bulk particulate material is also so small that the mere presence of the densification agent in the densified flowable bulk particulate material does not materially alter the bulk density of the combined particulate material and the remaining densification agent. This bulk density is only changed to a significant extent by severely agitating the combined particulate material and the densification agent, without any significant agglomeration of the particulate material, or at least to a much lower degree of agglomeration than is reached with the prior art pneumatic densification processes of which the Applicant is aware.

The bulk particulate material may have a mean particle size of less than 1 mm. Typically, the bulk particulate material has a mean particle size of less than 0.5 mm, even less than 1 µm, e.g. about 0.15 µm.

The method may include extracting dust from the vessel.

The ratio of the bulk density of the particulate material prior to densifying thereof, to the bulk density of the flowable densified particulate material may be at least 2 : 3. Preferably, the ratio of the bulk density of the particulate material prior to densifying thereof, to the bulk density of the flowable densified particulate material is at least 1 : 5, depending on the bulk density of the particulate material prior to densifying and the particulate material being densified. The ratio can be as large as 1 : 10, or even larger, e.g. 1 : 12 depending on the bulk density of the particulate material prior to densifying and the particulate material being densified.

The method may include allowing the concentration of the densification agent to reduce during the mechanical agitation of the bulk particulate material.

Thus, typically, the bulk particulate material is allowed to heat up during the mechanical agitation thereof. The concentration of the densification agent may thus be reduced as a result of vaporization of at least a portion of the densification agent.

When the densification agent is an aqueous liquid, the bulk particulate material may include water in, or water may be added to the bulk particulate material to, a concentration of more than 4 % by mass, with the densified bulk particulate material including less than 3 % water by mass. Typically, especially when the bulk particulate material is microsilica, when the densification agent is an aqueous liquid, the bulk particulate material includes water in, or water is being added to the bulk particulate material to, a concentration of between 4 % and 8 % by mass, preferably between 6 % and 8 % by mass, with the densified bulk particulate material including less than 1.5 %, preferably less than 1 %, water by mass.

CLAIMS:

1. A method of densifying a bulk particulate material to provide a densified flowable bulk particulate material, the method including mechanically agitating the bulk particulate material in the presence of a densification agent thereby to provide a flowable bulk particulate material of increased bulk density.

REPLACED BY ART 34 AMDT

2. The method as claimed in claim 1, in which the densification agent is a polar liquid.

3. The method as claimed in claim 1 or claim 2, in which the densification agent is an aqueous liquid.

4. The method as claimed in claim 3, in which the bulk particulate material, prior to densifying thereof, includes water as the densification agent in a mass concentration falling in a range with a lower limit of 0.4 % and an upper limit of 20 %.

5. The method as claimed in claim 4, in which the water is present in a range with a lower limit of 0.45 % and an upper limit of 15 %.

6. The method as claimed in any one of the preceding claims, in which the bulk particulate material is microsilica.

7. The method as claimed in any one of claims 1 to 5 inclusive, in which the bulk particulate material is selected from the group consisting of carbon black, fly ash, kaolin, and meta kaolin.

8. The method as claimed in any one of claims 1 to 5 inclusive, in which the bulk particulate material is selected from the group consisting of Mn_2O_3, Mn_3O_4, V_2O_5, cement and slag.

9. The method as claimed in claim 6, in which the microsilica has a particle size of less than 0.5 µm.

10. The method as claimed in any one of the preceding claims, which includes adding the densification agent to the bulk particulate material, prior to or during mechanical agitation of the bulk particulate material.

REPLACED BY ART 34 AMDT

11. The method as claimed in any one of the preceding claims, in which mechanically agitating the bulk particulate material in the presence of the densification agent includes at least partially confining the bulk particulate material and rotating a rotatable member submerged under the bulk particulate material about an axis of rotation to cause severe agitation of the material.

12. The method as claimed in any one of the preceding claims, in which mechanically agitating the bulk particulate material in the presence of the densification agent includes severely agitating the bulk particulate material with a rotatable member submerged in the bulk particulate material in a vessel and rotating about an axis of rotation which is upwardly extending, and inhibiting displacement of material downwardly past the rotating member during rotation of the rotatable member whilst allowing free movement of materials in the vessel above the rotating member.

13. The method as claimed in claim 11 or claim 12, in which the bulk particulate material is confined in a vessel having a closed bottom, the rotatable member being located immediately above the bottom of the vessel.

14. The method as claimed in any one of the preceding claims, in which a ratio of the bulk density of the particulate material prior to densifying thereof, to the bulk density of the flowable densified particulate material is at least 2 : 3.

15. The method as claimed in claim 14, in which the ratio of the bulk density of the particulate material prior to densifying thereof, to the bulk density of the flowable densified particulate material is at least 1 : 5.

16. The method as claimed in any one of the preceding claims, which includes allowing the concentration of the densification agent to reduce during the mechanical agitation of the bulk particulate material.

17. The method as claimed in claim 16, in which the bulk particulate material is allowed to heat up during the mechanical agitation thereof, and in which the concentration of the densification agent is reduced as a result of vaporization of at least a portion of the densification agent.

REPLACED BY ART 34 AMDT

18. The method as claimed in claim 16 or claim 17, in which the densification agent is an aqueous liquid, and in which the bulk particulate material includes water in, or water is being added to the bulk particulate material to, a concentration of more than 4 % by mass, with the densified bulk particulate material including less than 3 % water by mass.

19. The method as claimed in claim 18, in which the bulk particulate material includes water in, or water is being added to the bulk particulate material to, a concentration of between 4 % and 8 % by mass, with the densified bulk particulate material including less than 1.5 % water by mass.

20. Bulk particulate material densification apparatus which includes

a vessel for at least partially confining a body of the bulk particulate material;

a rotatable member which is arranged such that in use it is submerged in the body of bulk particulate material mechanically severely to agitate the bulk particulate material;

a densification agent inlet leading into the vessel; and

drive means connected to the rotatable member and capable of rotating the rotatable member about said axis of rotation when the rotatable member is submerged in the body of bulk particulate material.

21. Bulk particulate material densification apparatus as claimed in claim 20, which includes a densification agent outlet from the vessel to remove vaporised densification agent.

22. Bulk particulate material densification apparatus which includes

a vessel for at least partially confining a body of the bulk particulate material;

a rotatable member which is arranged such that in use it is submerged in the body of bulk particulate material mechanically severely to agitate the bulk particulate material;

a densification agent outlet from the vessel to remove a vaporised densification agent from the vessel; and

drive means connected to the rotatable member and capable of rotating the rotatable member about said axis of rotation when the rotatable member is submerged in the body of bulk particulate material.

REPLACED BY ART 34 AMDT

23. Bulk particulate material densification apparatus as claimed in any one of claims 20 to 22 inclusive, in which the rotatable member defines at least one material contacting surface facing substantially tangentially in the direction of rotation thereby to cause movement of material particles essentially towards or away from the axis of rotation at least on initial contact of the material particles with the material contacting surface.

24. A method of densifying a bulk particulate material as claimed in claim 1, substantially as herein described and illustrated.

25. Bulk particulate material densification apparatus as claimed in claim 20 or claim 21, substantially as herein described and illustrated.

26. A new method of densifying bulk particulate material, or a new bulk particulate material densification apparatus, substantially as herein described.